



Deterioration of left ventricular function following atrio-ventricular node ablation and right ventricular apical pacing in patients with permanent atrial fibrillation

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Aims Transcatheter radiofrequency ablation of the atrio-ventricular (AV) node followed by ventricular pacing has been shown to improve symptoms and quality of life of patients with atrial fibrillation (AF). It is assumed that function improves, but this has been less well demonstrated. The aim of this study was to assess the long-term effect of AV node ablation and ventricular pacing on left ventricular ejection fraction (LVEF) in patients with permanent AF.

Methods and Results All 12 patients studied had permanent AF for at least 12 months (mean age 70 years, range 41 to 78). LVEF was determined 6 days and 3 months after AV node ablation by radionuclide ventriculography, at a paced rate of 80 beats \cdot min⁻¹. Cardiac dimensions were measured by means of transthoracic echocardiography. No major changes in pharmacological therapy were made during 3 months follow-up period. LVEF showed a significant deterioration after 3 months follow-up period for the

group ($47.5 \pm 14.4\%$; 6 days after ablation vs $43.2 \pm 13.7\%$; 3 months after ablation, $P < 0.05$). There were no significant differences in left ventricular cavity dimensions directly after AV node ablation and 3 months later (LVEDD 51.2 ± 10.7 mm vs 52.6 ± 8.6 mm, $P = \text{NS}$; LVESD: 36.1 ± 14.2 mm vs 36.6 ± 9.7 mm, $P = \text{NS}$). Left atrial size did not show reduction 3 months after AV node ablation (50.8 ± 13.6 mm vs 51.0 ± 14.1 mm, $P = \text{NS}$).

Conclusion The restoration of a regular ventricular rhythm following AV node ablation for patients in permanent AF does not result in improvement in left ventricular function.

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Key Words: Atrial fibrillation, ablation, atrioventricular node, cardiac function.

Introduction

Atrial fibrillation (AF) is a common supraventricular arrhythmia, which leads to cardiac dilatation and dysfunction^[1]. Theoretically, the management of this arrhythmia including restoration of sinus rhythm or regular ventricular paced rhythm should result in an improvement in the patient's symptoms as well as in cardiac function. Some authors advocate achieving this by ablating the atrio-ventricular (AV) node followed

by right ventricular (RV) apical pacing. Although the advantage of a regular ventricular response seems to be important^[2], RV apical stimulation is not physiological because normal ventricular activation along the natural conduction system is bypassed and the ventricles are activated in an abnormal sequence^[3,4]. Chronic apical ventricular pacing is associated with myocardial cellular changes and leads to dysfunction of the left ventricle^[5,6]. However, some studies, including a prospective multi-centre randomized trial, indicated that exercise tolerance and the quality of life improved after AV node ablation and RV apical pacing^[7-9]. The reversibility of cardiac dysfunction after such intervention was one of the reasons that the concept of tachycardiomyopathy was introduced. However, it is clear that when atrial function is lost, ventricular performance will suffer in the long term. Since only limited and confusing data are available

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Table 1 Clinical and demographic characteristics of the patients

Pt. no.	Age	Sex	Duration of AF (months)	QRS duration (s)	Cardiac disease	Medication
1	67	F	12	0.12	SSS	3, 4, 7, 8
2	68	M	108	0.08	DCMP	2, 3, 4, 6
3	66	M	38	0.14	Atrial flutter	4, 6, 7
4	78	F	12	0.12	Atrial flutter	2, 3, 4, 6
5	70	F	24	0.08	Hypertension	4, 7, 8
6	74	F	48	0.12	ASD	1, 3, 8
7	66	M	48	0.08	Non obstr. HCMP	1, 2, 3, 6
8	41	M	48	0.08	VHD	2, 4, 7
9	67	F	12	0.12	SSS, Atrial flutter, Hypertension	1, 4, 7, 8
10	55	M	156	0.08	VHD	2, 3, 4
11	63	M	12	0.16	Hypertension	2, 3, 4, 7, 8
12	76	F	16	0.12	—	4, 8

SSS=sick sinus syndrome; AF=atrial fibrillation; F=female; M=male; DCMP=dilatative cardiomyopathy; ASD=atrial septal defect; HCMP=hypertrophic cardiomyopathy; VHD=valvular heart disease; in medication: 1=beta blocker; 2=ACE inhibitor; 3=diuretics; 4=digoxin; 5=vasodilators; 6=amiodarone; 7=Ca channel blocker; 8=other antiarrhythmics.

on the long term effect of AV node ablation and RV apical pacing, we aimed to conduct a study to assess long term effects of AV node ablation and RV apical pacing on the left ventricular performance using a completely different approach from previous investigators. To exclude the possible bias^[2,10,11] of comparing pre- and post-ablation states respectively in fast conducted AF and paced rhythm, we determined the left ventricular ejection fraction (LVEF) 6 days after (not before) and 3 months after AV node ablation in 12 patients with permanent AF.

Methods

Patients were eligible if they had permanent AF and if the ventricular rate could not be adequately controlled by drug therapy. From February 1999 to February 2000, 12 patients with permanent AF underwent ablation of the AV node and insertion of a VVIR pacemaker and RV apical pacing. There were six men and six women with an age range from 41 to 78 (mean 70) at the time of ablation.

Study patients

The clinical and demographic characteristics of the patients are shown in Table 1. All patients were in NYHA functional class II or III. The type of AF was permanent in all 12 patients. Only two patients had an increased QRS duration (140–160 ms) before AV node ablation. All had complete heart block after the ablation, with QRS duration less than 120 ms in 8/12 patients. There were no major changes in medication during the 3 month follow up period. VVIR pacing with rate responsive mode was used in all patients. For

LVEF measurements VVI 80 bpm pacing mode was temporarily programmed 1 h before measurement.

Ablation procedure

A temporary pacing electrode was inserted via a femoral vein into the RV before the ablation procedure. One patient already had a permanent pacemaker inserted. Third degree AV block was achieved using a conventional right sided approach in every case with radiofrequency energy. Webster D or F curve thermocouple mapping/ablation catheters were used to map the antero- and/or mid-septal region and to deliver radiofrequency (RF) energy. A permanent cardiac pacemaker was inserted 30 min after successful ablation. No major or minor complications related to RF ablation and pacemaker insertion were observed. Patients were subsequently followed-up in the outpatient clinic.

Evaluation of left ventricular ejection fraction (LVEF)

LVEF was measured with radionuclide ventriculography (red blood cells, marked with Technetium⁹⁹ pertechnetate, 25 mCi). Imaging was performed in 45° left anterior oblique (LAO). The R wave was used for gating, and 16–24 frames per cycle were stored until 400 000 counts per image were acquired. Measurement was made 6 days after and 3 months after the ablation procedure, always at the paced rate of 80 bpm.

Echocardiographic measurements

M-mode and cross-sectional echocardiograms were obtained at the time of measurement of LVEF by

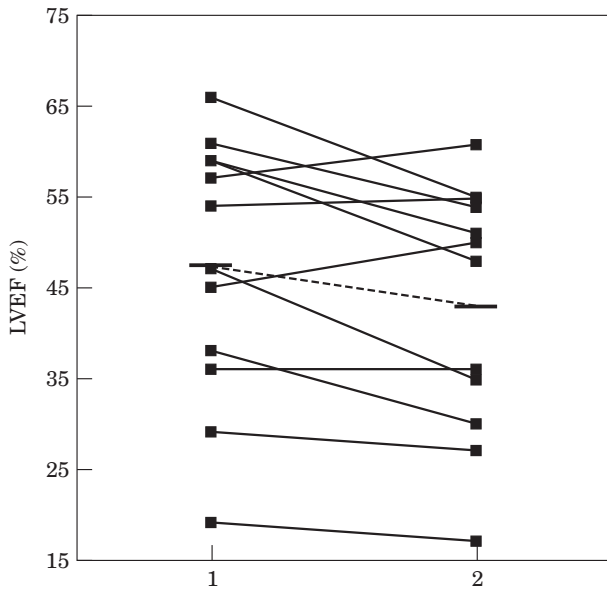


Figure 1 Individual representation of left ventricular ejection fraction (LVEF) 6 days after (1) and 3 months (2) after AV node ablation.

radionuclide ventriculography. Left atrial (LA) size, end systolic (LVESD) and end diastolic diameters (LVEDD) were measured according to the recommendations of the American Society of Echocardiography. Fractional shortening was calculated according to the following formulae: $FS\% = (LVEDD - LVESD) / LVEDD \times 100$. In all patients the echocardiograms were recorded in the same paced (80 bpm) rhythm. After analysis the pacemaker was reprogrammed to VVIR mode.

Statistical analysis: The measured values are expressed as mean \pm SD. Non-parametric data were compared using the Wilcoxon test. Correlation analysis was performed using the Pearson test. The level of significance was set at 0.05.

Results

Effect of AF on left ventricular function

The initial LVEF was lower in patients with longer duration of AF ($r = -0.74$, $P < 0.05$). A longer duration of AF was associated with larger LVEDD dimension ($r = -0.833$, $P < 0.01$) and LVESD dimension ($r = -0.795$, $P < 0.05$).

Effect of pace and ablate therapy on left ventricular function

The mean LVEF decreased from $47.5 \pm 14.4\%$ to $43.2 \pm 13.7\%$ ($P < 0.05$). Only two patients showed obvious ($>5\%$) improvement in LVEF (Fig. 1). Left

ventricular dimensions did not show significant change during 3 months follow up (Table 2).

Left atrial dimensions

LA dimensions did not show changes after AV node ablation and RV apical pacing (Table 2).

Fractional shortening (FS)

Fractional shortening did not show significant changes 6 days and 3 months after AV node ablation.

Discussion

The major finding of our study was that LVEF deteriorated 3 months after AV node ablation with chronic RV apical pacing. Secondly, the LV dimensions and the LA size did not show significant changes during the study period. Our data confirm the hypothesis that LV function becomes depressed after long term duration of AF.

Causes of LV dysfunction in patients with atrial fibrillation

It is now generally accepted that supraventricular incessant arrhythmias can lead to myocardial dysfunction and dilation^[1]. Factors contributing to HF when atrial arrhythmias are present are the loss of an effective, well timed atrial contraction and the fast and irregular ventricular response. These factors impair diastolic function and finally may lead to tachycardiomyopathy^[1]. Inappropriately fast heart rates occur even during minor exercise in patients with atrial fibrillation. This is accompanied by depressed heart rate at peak exercise in cases of left ventricular dysfunction^[12-14]. Therefore, the aims of improving function of the patients can be reached by restoration of sinus rhythm, but also (to a less complete extent) by control of the ventricular rate. It is believed that rate control, with drugs or RF catheter ablation alone is sufficient to improve the outlook of these patients. However, evidence has been presented that rhythm control in heart failure has disadvantages^[15]. Several investigators have considered it acceptable to randomize patients to rhythm or rate control, as many questions remain unanswered^[16].

LV function after AV node ablation

After ablation, pacemaker dependency is the rule, with implantation of a VVIR system when atrial electrical activity is no longer thought to be present. Although the advantage of a regular ventricular response is important^[2], RV apical stimulation is not physiological because normal ventricular activation along the natural

Table 2 Echocardiographic findings at the time and 3 months after RF ablation of AV node

	Six days after ablation (mm)	Three months after ablation (mm)	P value
LA size (mm)	50.8 ± 13.6	51.0 ± 14.1	NS
LV end diastolic dimension (mm)	51.2 ± 10.7	52.6 ± 8.6	NS
LV end systolic dimension	36.1 ± 14.2	36.6 ± 9.7	NS
Fractional shortening (FS%)	31 ± 0.1	31 ± 0.1	NS

LA=left atrial; LV=left ventricular; NS=non significant.

conduction system is not present or bypassed and the ventricles are activated in an abnormal sequence^[3,4]. Some investigators found significant improvement in left ventricular function after AV node ablation and RV apical pacing. Heinz *et al.* reported improvement of LV function after AV node ablation in patients with chronic AF and atrial flutter. This was attributed to decrease in end-systolic dimension^[17]. Rodriguez and co-workers showed a beneficial effect of the 'ablate and pace' therapy in patients with lone AF in the subgroup where the baseline LVEF was lower than 50%. They also showed a significant decrease in LV end systolic and end diastolic dimensions after ablation^[7]. A long term improvement in systolic and diastolic left ventricular function was reported by Edner *et al.* in patients with left ventricular dysfunction^[18]. Ablation of the AV node had no adverse effect on normal left ventricular function. In contrast to these findings, in the present study the LVEF decreased independently from the initial value (Fig. 1). In a recent study by Redfield *et al.* 63 patients underwent AV node ablation and pacing therapy with atrial fibrillation and reduced systolic function. Sixteen patients (25%) had improvement in systolic function after AV node ablation^[19]. These results lead to the concept of tachycardia-related cardiomyopathy which diagnosis should be considered in all patients in whom systolic dysfunction occurs subsequent to atrial fibrillation. More convincing are some studies showing that quality of life indices significantly improved after ablation of the atrio-ventricular node^[9]. In a prospective multicentre randomized study of Brignole and co-workers a mixed population of patients with AF and HF was recruited. The 'ablate and pace' therapy was superior to drug therapy in controlling symptoms, but the efficacy appeared to be less than was observed in previous uncontrolled studies. Importantly, objective cardiac performance did not show any improvement by the treatment. However, less hospital admissions and less physician visits were necessary after ablation^[8].

Methodological problems

The three major differences between the former and present studies are: the timing of the measurements, the composition of the study group and the method used for the measurement of LVEF. Some authors described

that less than 40% of their patients had heart failure, measured with some more or less objective parameters^[8]. Our study group was composed of patients with long standing AF, who all had signs of moderate to severe heart failure. Concerning the timing, all of the significant former studies compared LV function before and after AV node ablation^[7-9,17,18]. Some studies were retrospective and the timing of the measurement of LVEF varied in a wide time range^[7,17,18]. In our prospective study the timing was more appropriate. We tried to minimize the effects of possible acute haemodynamic changes caused by a restoration of a regular ventricular response. Therefore we compared the LVEF 6 days and 3 months after AV node ablation and pacemaker implantation exactly under the same conditions. One of the other possible explanations for the difference between the results of previous and the present study could be the significant difference in measurements. In this study, LVEF was measured by means of radionuclide ventriculography (RNV). RNV is highly reproducible and has an error of less than 3%. Probably RNV is less sensitive to the errors caused by the change in ventricular geometry during RV pacing. The formula used for routine calculation of LVEF during transthoracic echocardiography is based on constant ventricular geometry during contraction. The shape of the ventricle during RV apical pacing is changing, therefore a planimetry based measurement is more appropriate for the evaluation of LV function. We emphasize the importance of using RNV in further pacing studies assessing left ventricular function. Furthermore, none of the former investigators evaluated left ventricular performance exactly under the same conditions immediately and 3 months after AV node ablation^[7-9,17,18]. Both assessments of LVEF in this study were measured during the same 80 beats · min⁻¹ paced cardiac rhythm.

Survival after AV node ablation

Finally, the natural history of patients treated by AV node ablation is still not known. Sudden death has been reported in some subgroups of patients. It was first attributed to the technique of DC shock ablation^[20]. However, it was also observed after RF ablation^[21,22]. In a meta-analysis of 21 studies with a total of 1181 patients by Wood *et al.* the ablation and pacing therapy

showed that the calculated 1-year mortality was comparable with medical therapy^[23]. A considerable proportion of these deaths can be related to the acute effects of AV node ablation with QT prolongation and slow pacing rate and/or unreliable escape rhythms^[21,24]. Another subgroup of deaths was reported late after AV node ablation, mainly in patients with HF^[21,25]. The deterioration of pump function late after AV node ablation may play a role in this mortality. Therefore, careful adjustment of the medical therapy for these patients with LV dysfunction is very important including beta-blocker therapy ACE inhibitors, adjustment of electrolytes and avoidance of antiarrhythmic therapy^[26,27]. The follow up of these patients must not be limited to the technical control of pacemaker function.

Limitations of study

This study is of a relatively small number of patients. The change in ejection fraction is statistically significant, but may not have great clinical significance. A factor influencing this may have been the long duration of atrial fibrillation in most of the patients with consequent lack of ability to recover. Quality of life measures were not employed in this work. Future studies should include such measures to achieve more clinical relevance of the left ventricular function data. Follow-up of the patients in this report is only 3 months and the long-term effects on left ventricular function remain to be ascertained.

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